THE SORGHUM SUGAR INDUSTRY.

DEPARTMENT OF AGRICULTURE.

SPECIAL REPORT—No. 54.

ADDRESS

OF THE

HON. GEO. B. LORING

U. S. COMMISSIONER OF AGRICULTURE,

BEFORE THE

MISSISSIPPI VALLEY CANE-GROWERS' ASSOCIATION,

ST. LOUIS, MO.,

DECEMBER 14, 1882.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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GENTLEMEN: The foundation and development of a new industry in this country is entitled to all the respect and admiration which are won by great achievements on more prominent and conspicuous fields of action and thought. The record of military endeavor, by which we have founded and preserved our nationality; the history of the intense civil struggle out of which sprang our Federal Constitution; the brilliant years in which are recorded the efforts of the American mind to secure a foremost place in the bright realms of science and literature, will always challenge the warmest consideration of all thoughtful men. But the growth of our varied industries constitutes a chapter from which no student of man's progress can turn indifferently away. Standing as we now do in the midst of fertile and cultivated lands, whose annual product has reached the enormous sum of $9,000,000,000, we turn with profound respect to him whose axe struck the first blow in the primitive forest, and whose hand first planted the treasured seed for a scanty harvest in a virgin soil. We are never weary of the recital of the first feeble but determined efforts of Samuel Slater to establish cotton manufactures in this country, now nearly a century ago, or of the far-reaching courage and foresight which, twenty years later, led Lowell, and Appleton, and Jackson to contemplate from the snowy banks of the Merrimac the power of that rushing river, confident that a great industrial city would be founded there whose looms would clothe the world, and establishing a national enterprise with a capital of $250,000,000, employing nearly 200,000 persons, consuming nearly 1,000,000,000 pounds of raw cotton, and running more than 10,000,000 spindles. The early endeavors of our fathers to establish the woolen industry, with their little flocks and their household looms, an industry now employing a capital of $150,000,000, producing goods valued at $250,000,000 annually, consuming 200,000,000 pounds of wool, and employing more than 100,000 persons, are as fascinating as the fables of antiquity. We turn back from the enormous shoe and leather interests of our day, and contemplate with a natural incredulity the early labors of those who tanned a few domestic hides in domestic tan-vats, and manufactured slowly the rude and enduring shoes of the family by the fireside. We are lost in wonder before the seven and a half millions of tons of iron and steel produced in this country last year, and recall with still greater wonder the fact that within the lifetime of many a man among us this great industry was founded as a national enterprise. And as

we survey this vast field, we are always impressed with the evidences written there of the wise and well-directed enthusiasm, the deliberate judgment, the keen foresight, the unwavering courage, and the power of dispassionate investigation, which man has exercised in laying the foundation of the best forms of state and society on prosperous and well-educated industry.

It is in this honorable service that those who would develop a new source of wealth in our day are engaged, and whose efforts entitle them to all the light which science can bestow, all the encouragement which public spirit can give, and all the direction which sound, unbiased, practical wisdom can apply. Discoveries and inventions are made by investigators patiently pursuing their unobtrusive way, with minds and hearts superior to all natural obstacles and free from prejudice or passion. And so we approach the examination of every question in which man's welfare is involved, with an ardent desire to discover the truth and a natural inclination to lend all the aid in our power to the solution. Impelled by this desire and guided by this inclination, I have accepted your invitation to address you on this occasion, and to explore with you the industry to which you are devoted. I cannot expect to teach you the art of manufacturing sugar from any of the sugar-producing plants. But I have watched with great interest, both as a citizen believing in prosperous industry, and recently as an official engaged in encouraging the producing classes, all the efforts which have been made to perfect the work for which this association is organized. If I repeat what you already know, you will pardon me, and receive my assurance that I am desirous of inquiring into and advancing your industry by your own practical means and in your own practical spirit. My last official appeal for information was made to the manufacturers themselves who are engaged in establishing a profitable business and not in defending a theory.

The history of the sorghum industry in this country is curious and interesting, and familiar to you all. Twenty-five years ago or more I planted it on my farm in Essex County, Massachusetts, as a green forage crop for my milch cows. But at that time my attention was called to the plant as adapted to the production of sirup and sugar, and I studied with interest the essays of D. J. Brown, and the opinions of Dr. Charles T. Jackson, Dr. J. Lawrence Smith, Dr. Antisell, Professor Goessmann later, all declaring that the sugar contained in sorghum is crystallizable, but differing in their views as to the method by which this sugar can be produced: Dr. Smith asserting that "the sugar can be obtained by processes analogous to those employed for extracting sugar from other plants;" and President Stockbridge, of the Massachusetts Agricultural College, expressing the opinion still later, in 1881, that—

> The experiments with sorghum, as a sugar-producing plant, forever settled the fact that no known variety of it can be profitably employed for the purpose, unless chemical science can discover a law by which glucose can be changed for cane sugar.

During this long period of time in which the possibility of producing sugar from sorghum was discussed and experimented upon, the production of molasses had largely increased, and during the war many sections of the country depended upon sorghum almost entirely for their supply of this important commodity. Meanwhile an interesting discussion arose with regard to the time for harvesting the sorghum, and the condition of the seed at which the largest amount of sugar could be obtained. Dr. Jackson found that "the juice from stalks with quite ripe seed was by far the sweetest, while the green one which was just in flower contained but very little saccharine matter." Vilmorin thought that sugar could be "easily obtained in all cases where the cane can be sufficiently ripened." Dr. Jackson also says: "The unripe canes can be employed for making molasses and alcohol, but, as before stated, will not yield true cane sugar." Dr. J. N. Smith, of Quincy, Ill., in 1862, says: "The sirup from sorghum will not make sugar if the cane is cut before the seed is in the dough." Mr. Bollman, of Iowa, advocates "perfect maturity." William Clough, of Cincinnati, Ohio, in 1864, declared that the precise period most appropriate for harvesting the cane is "when the seed at the middle of the panicle is just beginning to harden or pass from the fluid or milky state." On the other hand, Professor Erni, in 1865, stated that "the juice from unripe cane readily crystallized." In 1866, the "Sorgho Manufacturers' Manual" stated that "the cane is in the best state for harvesting when part of the seed is beginning to turn black, or in other words, when the seed is in the doughy state." In 1867, a correspondent of the Department of Agriculture, says: "I take the sorghum when just fairly in bloom. In no case do I allow the seed to mature when I wish to make sugar, but for No. 1 sirup I let the cane mature." In 1869, Mr. Wm. Clough, editor of "The Sorgho Journal," says: "Do not mind the panicle if the juice has a clear sweet taste; even if the panicle is only in bloom, cut and work the cane." Again, in February, 1869, page 92, in an article entitled "Immature cane best for sugar," he says: "The theory that cane should be harvested before fully ripe, when designed for sugar, has been further confirmed by the experience of this year. The other idea, that the cane should be fully ripe, was never confirmed by facts." Page 58 it says: "The weight of evidence just now is in favor of cutting as the seed is passing from the milk to the dough state." In 1873 Mr. E. W. Skinner, of Sioux City, Iowa, says, in the annual report of the Department of Agriculture: "The best sirup is made from cane not fully ripened." In 1880, the "Sorgho Hand-book," published by the Blymyer Manufacturing Company, Cincinnati, Ohio, stated that "The cane should be cut when the seed is in the dough." In 1881, Professors Weber and Scoville, of the Illinois Industrial University, says: "The proper time to begin cutting the cane is when the seed is in the hardening dough."

Opinions have differed also with regard to the best time for working

the cane after it is cut. Dr. Smith, in his report to the Department of Agriculture in 1857, says: "The uncrystallizable sugar forms rapidly after the cane is fully ripe and recently cut." Hence, it is evident that no time is to be lost after cutting in expressing the juice. Dr. Cook, in the annual report of the Ohio department of agriculture in 1861, thinks the cane should be allowed to "season a few days" after being cut. Mr. F. A. Hedges, in the Annual Report of the Department of Agriculture for 1861, says: "After the canes have been topped, stripped, cut up and tied in bundles, they may be set up in the open air or, preferably, under shelter, and kept for some weeks." Mr. J. H. Smith, of Quincy, Ill., in the Report of the Department of Agriculture for 1862, says: "The cane should be brought to the mill and crushed on the same day." Mr. William Clough, in the Annual Report of the Department of Agriculture for 1865, says: "It would be best to allow but little time between harvesting and working the cane; and on no account should it be stored and allowed to remain long in large shocks." The Sorgho Manufacturers' Manual, in 1866, states that "the cane should be cut and shocked in the field, with tops on; and in this condition it may remain several months before being worked up, for the cane matures and forms more saccharine matter." Professors Weber and Scoville, in their report of 1881, Illinois Industrial University, say: "The cane should be worked up as soon as possible after cutting."

In the midst of this conflict of opinion the investigation of the sorghum cane as a sugar-producing plant was undertaken by the Department of Agriculture in 1878, and has been continued to the present time. Elaborate scientific analyses have been made year after year in the laboratory, and an attempt has been made to manufacture sugar in a mill erected on the grounds of the department from sorghum grown on lands lying in and around Washington. The results of these operations I desire to submit to your consideration, believing as I do that the test of all economic science lies in the hand of the producer, and that this association of practical sorghum growers and sugar manufacturers is the jury before which every experiment is to be tried for a verdict.

I submit the conclusions already arrived at by the chemist of the department as laid before me. He informs me that "the following conclusions may be fairly claimed as having been established by the experiments" made in the department:

1. The presence in the juices of several varieties of maize of an amount of sugar greater than is found upon the average in the juices of the sugar beets grown in the United States and analyzed by this department.

2. The presence in the juices of several varieties of sorghum of an amount of sugar equal to that present in the average juice of the sugar cane of Louisiana.

3. The possibility of recovering in the sirups as large a percentage of

the sugar present in the juices of maize and sorghum as is recovered from the sugar-cane juice, and by processes and appliances identical with those employed in the production of sirups from sugar cane.

4. The number of days from planting when these several varieties of sorghum have attained approximately their maximum contents of sugar, from 92 to 139 days.

5. The number of days during which these several varieties retain approximately their maximum content of sugar and may be most profitably worked up from 92 to 122 days.

6. That the increase in sugar during the later period of development in the plant is not caused by a drying up of the plant.

7. That in this latitude, during ordinary seasons, there would be a period of three months' duration in which one variety or another of sorghum would contain its maximum content of sugar and could be most profitably worked therefor.

8. That the so-called gum which often causes trouble in the purging of the sugar from sorghum is not present in the juice of the plant, but is a product of manufacture, and is often present in but small quantity; and its formation, therefore, may probably be entirely prevented by further investigation.

9. That sorghum and maize, after being cut up, are in great danger of having the sugar present in the plant inverted, and that therefore the only safe way is to work up the cane within a few hours at most after cutting.

10. That for the purpose of sugar production, immature cane is worse than worthless, and should therefore be carefully kept apart from such cane as is intended for the production of sugar, and should be worked up only for sirup. Consequently a uniform stand of cane should be secured at the first planting, and such varieties of the sorghum are to be preferred as do not have a tendency to throw up suckers.

11. That the result of a heavy rainfall, even after a prolonged drought, did not effect the quantity of juice nor increase the water in the sorghums.

12. That the effects of frost depended entirely upon the condition of maturity of the sorghum, being in one case disastrous and in another without apparent effect.

13. That the juice after defecation could be kept over night before being evaporated to sirup without suffering any inversion of the sugar present.

14. That water could be added to the juice during defecation without causing any loss of sugar.

15. That the specific gravity of the juice furnishes a convenient means by which the amount of sugar may be determined.

16. That the results obtained by analysis were in very close agreement with those obtained by the polariscope.

17. That the excessive drought caused an increase in the sugar of the

juice, but a diminished crop of cane in weight; and provided the crop has secured a good start, it is capable of sustaining severe drought, but unless a good start is secured, the effect of the drought is disastrous.

18. That an excess of lime in defecation has the effect to destroy glucose and darken the sirup produced, but did not affect the sucrose present.

19. That the seed of the sorghums is about identical in composition with maize and probably of equal nutritive value.

In addition to the points thus determined in the opinion of the chemist, I learn from him that he expects to ascertain from the analyses now going on at the Department—

1. The absolute and relative value of new varieties as compared with varieties examined in past years.
2. Proximate composition of juices of sorghum.
3. Loss of sugar in begasse.
4. Effect of stripping.

These are the points which have been and will be laid down by the chemist of the Agricultural Department for the benefit of those who are engaged in the industry, both as farmers and manufacturers.

At the request of the chemist of the department, I called upon the National Academy of Sciences, on January 30, 1882, to investigate the processes by which these conclusions had been reached in conformity with the act of Congress incorporating that body. The report of a committee appointed to make the investigation was submitted to me in May following, was withdrawn by the president and secretary of the Academy for revision and "such action as the Academy might deem necessary." On the 15th of November last the report was returned to me essentially modified, and in such form that it could be given to the public, to the satisfaction of the Academy and the instruction of the community. An abstract was at once prepared and published by the daily press: and the entire document, which is elaborate and voluminous, will soon be issued in special form by the Agricultural Department. I regret that its completion by the Academy was so long delayed, and that its magnitude will prevent an earlier publication, even while I congratulate you that the delay furnished an opportunity for the committee to secure valuable information of the work done during the season of 1882, and to lay before the country the latest knowledge of the practical manufacturer from Champaign, Ill., Rio Grande, N. J., and Ashtabula, Ohio. I am happy, however, to be able to lay before you what the Academy call "the facts relating to the economical production of crystallizable cane sugar on a scale profitable to the farmer and manufacturer, from sorghum, in this country, so far as developed by the existing state of the laboratory and field practice."

1. That these plants develop at maturity, and when the seed is ripe a maximum of cane sugar and a minimum of glucose.

2. That the maximum of cane sugar in sorghum juices is found associated with about one-tenth its weight of grape sugar (glucose), and not far from one-fifth its weight of solids not sugar, viz: ash, gum, chlorophyll, albumen, wax, aconitic acid, &c.

3. That after maturity the relative amounts and proportions of the chief factors vary but little, even for a period of three months or more, provided the season does not change; *e. g.*, an early maturing variety of sorghum holds its own until frost; a later variety has a shorter working period.

4. That while varieties of sorghum differ greatly in rapidity of growth and time of reaching maturity, in size, weight, and consequent yield per acre, it appears that all varieties of sorghum resemble each other in developing at maturity, under the same conditions, nearly the same maximum percentages of cane sugar, glucose and solids, the cane-sugar maxima varying from 14 to 16 per cent. of the total weight of the expressed juice, the other factors being as stated under 2.

5. The soil best adapted to the growth of a good crop of sorghum for sugar appears to be a sandy loam. This plant thrives on soils and in climates too light and dry for maize, and makes the best "stand" when grown closer than Indian corn admits, in a given locality.

6. While good sirup may be produced from sorghum, as a domestic industry, and on a limited scale, over a very wide range of country, the successful production of crystallized sugar on a commercial scale, appears to demand the skill and appliances of a sugar-house conducted in a systematic manner and with ample capital.

7. The best results in sugar are obtained only when the ripe cane is manufactured on the same day in which it is cut from the field.

8. The seed of ripe sorghum is a valuable feed crop, equal, for fattening animals, to maize, and in product is equal from 2½ to 4 bushels per ton of cane.

9. About forty per cent. of the juice of sorghum is lost in the begasse, as it is, to nearly the same extent in tropical sugar cane; more than one-half of which loss may probably be saved to the crop by process of displacement yet to be perfected.

10. Of other residual products, the scum and sediment, rich in various elements of fertility, are now thrown away. The begasse, when treated by a pulping machine, gives a valuable paper stock. Treated as a fertilizer, the begasse will return to the soil a portion of what the plant has borrowed from it in its growth. In regions where fuel is dear, the begasse can be used with advantage as fuel.

I think many of these conclusions can be properly and profitably discussed by this convention.

Having laid before you the points which have been developed by the scientific work of the Agricultural Department, I will now call your attention to the effort made by the department to manufacture sugar, and to point out the way by which sorghum could be raised as an agricultural crop, and by which it could be converted into sugar as a manufacturing industry.

In my report to the President, November 25, 1881, I made the following statement:

Congress at its last session appropriated the sum of $25,000 for expenses of machinery, apparatus, labor, &c., to continue experiments in the manufacture of sugar from sorghum and other sugar-producing plants, the appropriation to be immediately available. My predecessor had purchased the machinery and apparatus, appointed several additional chemists, and made contracts with parties residing near this city to raise sorghum cane for experiment. Upon assuming the duties of my office, I found growing 135 acres of sorghum, consisting of 52 varieties. Having engaged the services of an expert in sugar-making who was highly recommended for the position, operations were commenced at the mill on September 26 and continued with slight interruptions until the latter part of October, at which time the supply of cane became exhausted. Forty-two acres of the sorghum were overtaken by frost before being sufficiently ripe for use, and the crop was so badly damaged as to be regarded unfit for experiment.

The following condensed statement gives the results of the operations for the season:

Acres of cane passed through mill	93.5
Yield of cane per acre in pounds	4,903
Pounds of cane crushed	458,444
Gallons of juice obtained after defecation	26,794
Pounds of sirup obtained	34,985
Gallons of sirup obtained	2,977
Pounds of sugar obtained	165

The expenses of raising the cane were as follows:

Rent of land	$1,854 00
Labor and superintendence	3,474 22
Tools and implements	347 13
Hire of teams and hauling of cane to mill	914 10
Total	6,589 45

Expense of converting the cane into sirup and sugar.

For labor and running mill	$1,342 11
Coal and wood	325 48
Total	1,667 59

The cost of 2,977 gallons of sirup and 165 pounds of sugar was $8,257.04, not counting the wear and tear of the machinery, or the interest on the outlay for the mill.

The crops brought to this mill were raised by Mr. S. M. Golden, Dr. Dean, each on his own land, and by Mr. Culver, on land hired of Mr. Carlisle Patterson.

Mr. Golden's land was in good tilth, had been previously cultivated, and was a warm somewhat light loam of clay and sand intermixed. He states to me that he planted 28¼ acres, as follows: 6 acres planted May 4–6; 2¾ acres planted May 7; 7½ acres planted May 8–10; 12 acres planted May 17–28.

The 12 acres were of the Honduras variety, and the remainder consisted of 51 different varieties. He says he was continually replanting and filling in the rows, until about June 15. At that time, notwithstanding all his efforts, at least ¼ of the land had no stand. The department paid him a rent, $12.50 per acre for the land for the season, and for all the labor employed on the crop. He delivered from his 28¼ acres 105 tons of sorghum, the entire crop being 110 tons. This crop cost the government $1,367.25.

The land of Dr. Dean resembled that of Mr. Golden. It consisted of 40 acres, rented and managed in the same manner as the preceding. He began planting May 20 and completed the first planting May 25. From that time until July 15 he continued to replant. At this last date, as he reports to me, a crop of Early Amber was planted, which was ripe on September 15. He delivered 50 tons to the department, and the rest was frost-bitten and rotten in the field. This crop cost the government $2,000.

The land rented of Mr. Carlisle Patterson, consisting of about 65 acres, was divided into two lots, according to the statement of Mr. Culver who had charge of it, one of which was planted with Early Amber, and the other with "Link's Hybrid." On Tuesday, May 10, the planting of this land commenced, and the work was renewed until June 18, when it was planted for the third time. The land was a pasture which had been heavily fed for years, and was plowed just before planting. You will not be surprised to learn from Mr. Culver that the first "lot of seed was nearly all destroyed by worms" on land like this, and that the worms continued their ravages until they were driven away by rolling the seed in coal-tar. The amount of cane delivered to the department from this land was about 100 tons. The cost of this crop to the government was about $4,000. No manure or fertilizer of any kind was used on these parcels of land, either on the worn-out pasture which was filled with wire-worms, or on the old land which had been previously cropped. The land of Mr. Patterson was a light sandy loam.

This agricultural operation should be seriously considered. Mrs. Glass in her famous English receipt for cooking a hare commenced by saying, "First catch your hare." To those interested in the sorghum industry, whether on the land or in the mill, the foremost injunction is "First get your crop," by the exercise of all that wisdom in the selection of land, and the modes of fertilizing if necessary, and the care of the crop, which enables the farmer to raise the great corn crop of the West, and the valuable special crops of the East. On the ninety-three acres harvested, the yield was about two and a half tons to the acre. The yield of sirup and sugar from this was small. The result in the large mill and in a a smaller one devoted to special processes was very unsatisfactory. I should say the lesson learned from all this was what to avoid and not what to follow. To the farmers it gave so poor encouragement, that when I endeavored to employ them to raise a crop for the work of the present season, one of them experienced in the efforts of last year proposed to raise it for me at $15 per ton, and an inexperienced one proposed to raise it for $6, and finally concluded that he had better not raise it at all. At this stage of the proceedings, having satisfied myself that the experience of practical men endeavoring to work to a profit, was especially necessary for the development of the industry, and that a judicious selection of locality is necessary for this as for every other industry, I called upon the manufacturers throughout the country to contribute the results of their experience during the present year. To a circular issued by me in June last, calling upon them to furnish me information upon their various modes of manufacture and the results, I have received nearly a hundred responses, and I feel confident that much valuable knowledge will be compiled from these communications.

I have also secured from other sources accounts of work now going on, which I feel confident will be interesting to this association.

In the report of the Academy of Sciences to which I have alluded, I

find many references and opinions with which you are all familiar; and I also find elaborate statements of work performed during this last summer and autumn to which I call your attention, as the most recent information we have upon this subject.

The committee having in the first draft of their report presented the condition of the Rio Grande Sugar Company in 1882, state, under date of October 12, 1882, that they are able to add the following information obtained by a personal examination of the plantation and sugar works of this establishment. They say:

This company (the Rio Grande Sugar Company, Cape May County, New Jersey,) are the present owners of their works, and also of 2,400 acres of land, chiefly of a light and not fertile soil, being on the peninsular between Delaware Bay and the sea, within five or six miles of Cape May and 75 miles south of Philadelphia. April 19, 1882, and following, they put in, of Amber cane, 958 acres; Linke's Hybrid, 25 acres; Early Orange, 23 acres; and Honduras, 2 acres; in all, 1,008 acres. Warned by former experience the company determined to own and cultivate its own cane. The very cold and wet spring occasioned the loss of a considerable portion of the first planting, the loss being also due in part to deep planting by unskillful hands. The deficient portions were replanted in June, leaving such portions of the first planting as came up to grow together with the second planting. This circumstance worked considerably to the injury of such portions of the crop, and reduced the exponent of sugar notably. Notwithstanding this untoward circumstance the crop, as we first saw it, near the close of September, presented a noble appearance of vast fields of luxuriant cane ready for the rolls, and still full of vigor and of a deep green color. The Amber cane stood about 8 to 10 feet in height; the Orange and Linke's Hybrid were higher, being from 12 to 14 feet. The Amber cane only was ripe at that time, and the harvesting had been in progress from the 28th of August, at the rate of 120 to 150 tons of the cane delivered daily to the mill, which is the present limit of the floors to accommodate the sugar wagons. The mill is a powerful apparatus of three rolls, each 5 feet long and 30 inches in diameter, driven by a steam-engine of 125 horse-power, crushing the cane with an opening of only one-sixteenth of an inch between the rolls. The stalks are not stripped, only the dead heads are removed in the field. This mill is capable of crushing 300 tons or more daily, but the floor space of the works limits the outpost, as before stated. The product of sugar exceeds the most sanguine expectations of the projectors.

The Amber cane, on a large area, stands not less than 10 tons to the acre on about 700 acres. The exact figures for the whole crop can be given only when the account is fully made up. Each day's cutting is accurately recorded, and so can now be safely stated. We saw the "strike" of the vacuum-pan of 1,600 gallons on the 28th of September, and again on the 11th of October, filling nine wagons of one ton capacity each with "melada," yielding 2½ or 3 barrels of sirup to the ton. The yield of sugar to the wagon would be, by estimate, greater by about half a barrel (the barrel holds 355 pounds) if more time could be allowed for it to stand before going to the centrifugals.

From the mill the green juice flows to a tank of 1,000 gallons capacity, whence it is pumped to defecators, after which it is hurried through the open pans to the vacuum-pan, where it is reduced to about 32° B., and thence to the larger pan of 1,600 gallons, where it is raised to about 45° B., or a temperature of about 140 F. There are two "strikes" of this pan daily. The lack of space for cooling compels, at present, the working of the melada in the centrifugals, of which there are four, before it is completely cooled, so diminishing, as just stated, by probably a half barrel, the yield of "firsts."

We examined the books of Henry A. Hughes, the superintendent, who is a sugar boiler

of twenty years' experience, which showed the juice of the daily workings, as tested by polariscope, to have a coefficient of from 10° to 12° for the new juice, which is polarized several times daily. For the week ending the day of our first visit 656 tons of cane were crushed, yielding 115 barrels of sugar of 88°, and 89 barrels of molasses of 47°. The first sugar was equal to 63 pounds to the tons of cane crushed.

The fertilizers used on the land of this plantation this year were about 25 bushels of lime, followed by 150 pounds of Peruvian guano, having as much sulphate of ammonia added as raised the nitrogen to 8 feet. This guano cost $53 per ton. A few acres were treated as an experiment, with fair results, with barn-yard manure; on about 20 acres fish guano alone was used, the effect of which was to reduce the available sugar by about 1° on the polariscope. On the whole the lime, the guano, and stable manure gave good results. Greensand marl, which abounds in New Jersey, remains to be tested hereafter. The crushing of the cane with the leaves settles one of the "sorghum questions" on which there has been much difference of opinion. In practice, on a large scale, the removal of leaves would involve an impracticable amount of labor. In the 1879 Report of the Department of Agriculture, p. 59, are experimental results showing an increase of both juice and sirup from the crushing of the entire plant (seed excepted). A small loss of available sugar and a gain of sirup will probably result from crushing the blades with the stalks, a subject requiring further examination. It is by no means improbable that in the plant's life the sucrose is elaborated directly in the leaf, and is gradually transferred to the stalk, where it accumulates.

The fall returns for the crop of this year will not be in before the closing of this report. But we are able to state from a communication of date November 8, 1882, from the president, that the probable results of the season's work ending November 11 are as follows: 6,000 tons of cane, 950 barrels of first sugar, and 1,100 barrels, 50 gallons each, of molasses. The seed is not yet measured, and a full balance sheet remains to be made up, which may, perhaps, come in season to be added to this report.

The Orange cane turns out rather better than the Amber, being richer in juice, and with an average test of 13° B.

This committee have received from Mr. Knight, the sugar refiner of Philadelphia, a barrel of the sugar, sample of a lot of 350 barrels refined by him, of the Rio Grande Sugar Company. It ranks, on the independent judgment of experienced growers to whom we have shown it, as "C" sugar.

Analyses of the soils of different fields are now in progress to determine, if possible, the causes which influence such very unlike productiveness as the experience of the season of 1882 has shown to exist—the differences of yield being per acre: 3½ tons with guano and no lime; 5½ tons with guano and no lime; 7½, 8, 15, 17 tons respectively.

Since the completion of this report of the Academy, I have received the following statement with regard to the product of these works in 1882: sugar, 319,000 pounds; molasses, 40,000 gallons.

It will be observed that no reference is made in the report to the methods employed in the manufacture of the sugar. It is to be presumed, therefore, that they are such as are usually employed in the production of cane-sugar.

The committee of the Academy have also laid before me an interesting statement of the work of the "Champaign Sugar and Manufacturing Company," Champaign, Ill., as follows:

The undersigned have the honor to present to you the following report on the manufacture of sorghum sugar for the year 1882. Our report is necessarily incomplete, as we are still in the midst of our season's work; but the gratifying results thus far obtained will, we hope, warrant our reporting the data on hand.

HENRY A. WEBER.
MELVILLE A. SCOVELL.

CHAMPAIGN, ILL., *October* 28, 1882.

As a result of the experiments carried on by the writers in the seasons of 1880 and 1881, the Champaign Sugar Company of Champaign, Ill., was organized. The object of the company was to carry out, on a commercial scale, the production of sugar from sorghum, as was indicated by the laboratory experiments. The company was organized with a capital stock of $25,000. The total expenditure for building the works and raising the crop, however, was more than $30,000. The main building is 40 by 60 feet, and three stories high, with a lean-to, 45 by 30 feet, covering the engines and crushers. Near the main building are situated the boiler-house, with ninety horse-power boilers, and a kiln with twelve retorts for revivifying the bone-black.

For the sake of convenience, the description of the apparatus will be given in connection with the process followed in the manufacture of sugar and sirup.

The cane is conveyed by means of a carrier fifty feet in length, to the first mill, a "Cuba" No. 4, manufactured by Geo. I. Squier, of Buffalo, N. Y., who kindly consented to the use of his rubber springs for our second mill, which was originally one of the rigid kind.

After leaving the first mill the begasse is moistened with a spray of hot water, and is conveyed by means of an intervening apron to the second mill. By the use of this second mill the sugar which is left in the begasse after passing through a single mill, as is pointed out in the report of our experiments, is practically all recovered.

The juice from the two mills is pumped together to the juice-tanks, which are placed at the top of the main building, and have a capacity of about 3,000 gallons. From here it is drawn to the defecators, where it is exactly neutralized with milk of lime in the cold, heated to the boiling-point, and thoroughly skimmed. These defecators are made of wood, lined with galvanized iron and supplied with copper coils for heating. Four of them have a capacity of 660 gallons each, and one of over 1,300 gallons. After settling, the juice is allowed to run into the evaporators, where it is concentrated to a density of 25° Baumé. The evaporators are two in number, eight feet in diameter, made of copper, and supplied with copper coils. From the evaporators the liquor runs into settling-tanks, and next through bone-coal filters. The filters are four in number, 2 feet in diameter, and twelve feet high. The liquor is next drawn up into the vacuum-pan, where it is concentrated to melada. The crystallization of the sugar takes place in the vacuum-pan, and could at once be run into the mixer and centrifugals. Owing to the fact that only one centrifugal has thus far been supplied, the strikes from the pan are usually run into crystallizing wagons and placed in a warm room until the sugar can be "swung out." There are fifty of these wagons having a capacity of 120 gallons each.

The quality of the sugar produced is unobjectionable in regard to taste and color. It grades as extra yellow "C," and sells readily at the factory at 8½ cents per pound, in lots of five barrels. The molasses is of a dark color, but still is rich in cane sugar. It is stored up in barrels and will be kept until the cane is all harvested, when it will either be refined or worked over for a second yield of sugar.

The company raised 190 acres of cane, 8 acres of which is "Kansas Orange," about 40 acres "Early Orange," and the rest "Early Amber." Private parties planted about 100 acres more, all of which was Early Amber, with the exception of one field of Early Orange, containing 12½ acres.

The company began working up their Amber canes on September 21. An analysis of the juice was made with the following result:

Specific gravity, Brix		14.8
Cane sugar	per cent	8.10
Grape sugar	do	3.63

The best Amber cane of the company was grown on sod ground, the field containing 50 acres. The composition of the juice of this field on October 21, was as follows:

Specific gravity		1.060
Cane sugar	per cent	10.17
Grape sugar	do	2.48

Owing to the lateness of the season, one continuous run was made, and the cane raised by private parties was worked up with the company's cane, so that it will be impossible to give the yield per ton and acre before the close of the season's work.

One field of Early Orange, grown by Mr. J. G. Clark, has been harvested by itself and the products kept separate. Of this field and variety of cane, exact data can be given.

The composition of juice, October 24, was as follows:

Specific gravity		1.070=16°.3 Brix.
Cane sugar	per cent	10.82
Grape sugar	do	3.54

Number of acres in field, 1225.

Total amount of cane stripped and topped	tons	156
Yield per acre	do	12.5
Amount of juice	gallons	20,939
Weight	pounds	185,947
Per cent		59.6
Weight of melada	pounds	25,920
Weight of sugar	do	9,900
Weight of molasses	do	116,020
Quantity of molasses	gallons	1,456
Yield of sugar, per acre	pounds	790
Yield of molasses, per acre	gallons	116.5

In this statement the amount of water added in moistening the begasse before passing the second mill has been deducted from the total amount of juice obtained.

The melada obtained from the Amber cane is fully as rich in sugar as that obtained from the Orange. The yield of sugar and molasses, per acre, will be lower for some of the fields of Amber, but for others it will be fully as high, and in a few cases perhaps higher.

It is not more than fair to add that for this section of the country the season has been very unpropitious for the proper development of sorghum cane. This will be seen at a glance by comparing the analysis given here with those made in this locality last year and the year before, as given in our report. The necessary hot summer temperature for the production of a high percentage of sugar was entirely wanting. But on the whole, the sorghum sugar industry is to be congratulated, for this cold, wet season, as the flattering results which we are, nevertheless, obtaining here, will forever silence the claim that sugar can be made from sorghum only under the most favorable circumstances.

Since the above account was reported to the Academy I have seen it publicly stated that this company has produced about 125,000 pounds of sugar and 22,500 gallons of molasses during the last season. They estimate the return at $75 per acre.

Valuable statements have also been made with less detail than those I have fully laid before you, by Mr. Magnus Swenson, of the University of Wisconsin, for the year 1882; Capt. R. Blakesley of the Faribault Refinery, Minnesota, for the year 1881; Mr. John B. Thomas, of the Crystal Lake Refinery, Illinois, for the year 1881; Mr. A. J. Russell, Janesville, Wis.; all of which have been submitted to me by the Academy.

The following letter from Mr. Henry Talcott, president of the Jefferson Sugar Manufacturing Company, Ashtabula, Ohio, addressed to the

Department of Agriculture. I also find in the appendix to the report of the Academy. Mr. Talcott, under date of November 2, 1882, says:

I have been endeavoring to secure a practical method of producing the same results which they have obtained at the Rio Grande Company's works, where I have just been for myself—that our farmers could all adopt with small means, and make the industry universal. I think our company can show the world as complete success in about four weeks as the Rio Grande have done, on a much smaller and more simple scale. We are now crushing and boiling from ten to fifteen tons of cane stalks daily; have been doing this for four weeks past; our returns, in yield, are the same in substance as the Rio Grande; but, unlike them, we have had ten or fifteen good hard white frosts, some of them hard enough to freeze ice on water thick as window-glass. Our cane was standing in the fields; we are yet cutting it. I had ten acres of it on my own farm. We see no ill effects from it (the frost) in our work. We have made just as good a yield of juice; it makes just as good sirup and sugar, and all we have lost, as far as we can discover, is the leaves for our cattle fodder. Mr. G. C. Potts wished me to notify you of this fact on my return home; also to send you some samples of our work. We cook in open pans, by the Stewart process, only much more perfect than he ever did his work (except in theory). F. C. Knight analyzed our mush sugar and finished sugar yesterday, in their refinery, and pronounced it the purest and best sugar they ever saw. The sugar was our "second." This year's stock is still in our hot-room granulating slowly, for we dare not cook it dry in open pans, for we are so liable to scorch it when near done, so we make time and warm room do part of the work. We shall not use our centrifugal until the close of the month; shall then have from sixty to eighty thousand pounds of mush to work over. I shall make a complete and clear report of it to the department as I possibly can. I shall also visit the Champaign Works in Illinois next week and compare notes with them. I have an invitation to do so, and must see the bottom of this industry so far as it is practically developed. Of course the vacuum-pan and animal-bone filter make the refined sugar at once; a specimen of it they sent me yesterday, and I inclose a little of it for you; but this expensive machinery, if it is more profitable, cannot be made to come in general use. Our farmers must do this work as handy as they can make good butter and cheese, to get them into it in any great numbers. Our factory are learning many of them to do the work, and several others are to-day making mush sugar at their own molasses factories, while we furnish them solution B, and do their centrifugal work. I will send a little sample of sugar we purged yesterday for Mr. P. A. Upp, of Edgerton, Williams County, Ohio, who made it under our directions, and then brought to the factory to see our works, and with his own eyes see finished sugar of his own make. I guess he was as well pleased with the result as any fond mother could well be with her first born. He returned home with his sugar, and said he should now go shouting among his own people, for he had accomplished well what his people all said was an impossibility.

The committee of the Academy state in this connection:

It is from the States of New Jersey and Illinois that we are able to cite examples of success on so large a scale and attended with such an unequivocal result as fairly puts to rest any doubts as to the production of sugar on a great scale in a northern climate with a commercial profit.

Hence it is that I have quoted the reports from Rio Grande and Champaign.

These significant communications adopted by the committee of the Academy I present here for your consideration. I regret that I cannot add statements from manufacturers who will soon supply the Agricul-

tural Department with reports covering the following points submitted to them in my circular of June 6, 1882, viz:

1. An accurate account of the number of acres of sorghum brought to the mill; the number of tons of cane manufactured; the yield of sorghum per acre; the mode of fertilizing; the time of planting; the time required for maturing the plant; the value of the crop as food for cattle, after the juice has been expressed.

2. The amount of sugar manufactured; the amount yielded per ton of cane; the quality of the sugar; the amount of sirup manufactured; the process of manufacturing; the machinery used; the success of the evaporator, the vacuum-pan, and the centrifugal in the work of manufacturing.

3. The number of hands employed in the mill; the cost of fuel; the cost of machinery; the wages paid for labor; the price of sorghum at the mill, if not raised by the manufacturer.

The replies I shall receive to this circular will be published as soon as they can be properly arranged, and I doubt not they will contain a large amount of valuable and interesting and accurate information.

It will, I doubt not, be gratifying to ascertain the extent of the sorghum industry in the country; and I have endeavored to arrive at this as far as possible by means of circular letters addressed to correspondents in every county in the Union. I have received imperfect reports from the following States, and I submit them in this connection, not as a complete return, but only as indicating to a certain degree the extent of the industry. During the season of 1882, 24 counties in Arkansas have produced 729,500 gallons of sirup and no sugar, as returned; 12 counties in Alabama have produced 520,125 gallons of molasses and no sugar; 5 counties in Dakota have produced 139,648 gallons of molasses and no sugar; 42 counties in Georgia have produced 568,023 gallons of molasses and 5,150 pounds of sugar; 35 counties in Indiana have produced 618,410 gallons of molasses and no sugar; 32 counties in Illinois have produced 660,633 gallons of molasses and 13,200 pounds of sugar; 38 counties in Iowa have produced 491,949 gallons of molasses and 731 pounds of sugar; 32 counties in Kansas have produced 950,947 gallons of molasses and 100 pounds of sugar; 35 counties in Kentucky have produced 853,709 gallons of molasses and no sugar; 10 counties in Louisiana have produced 81,800 gallons of molasses and no sugar; 37 counties in Missouri have produced 1,408,350 gallons of molasses and 2,400 pounds of sugar; 22 counties in Minnesota have produced 267,483 gallons of molasses and 100 pounds of sugar; 16 counties in Michigan have produced 46,503 gallons of molasses and no sugar; 15 counties in Mississippi have produced 530,100 gallons of molasses and 2,200 pounds of sugar; one county in Maryland has produced 1,200 gallons of molasses and no sugar; 2 counties in New Jersey have produced 42,000 gallons of molasses and 319,000 pounds of sugar; 8 counties in New York have produced 101,261 gallons of molasses and 90,150 pounds of

sugar; 19 counties in Nebraska have produced 177,420 gallons of molasses and 60,000 pounds of sugar; 29 counties in North Carolina have produced 371,300 gallons of molasses and 1,500 pounds of sugar; 19 counties in Ohio have produced 201,555 gallons of molasses and 275 pounds of sugar; 1 county in Pennsylvania has produced 1,200 gallons of molasses and no sugar; 6 counties in South Carolina have produced 292,500 gallons of molasses and no sugar; 31 counties in Tennessee have produced 2,122,700 gallons of molasses and 50 pounds of sugar; 47 counties in Texas have produced 958,940 gallons of molasses and 800 pounds of sugar; 7 counties in Utah have produced 67,480 gallons of molasses and 10,000 pounds of sugar; 20 counties in Virginia have produced 132,871 gallons of molasses and no sugar; 13 counties in West Virginia have produced 379,200 gallons of molasses and 125 pounds of sugar; 14 counties in Wisconsin have produced 281,300 gallons of molasses and 5,000 pounds of sugar. In all, 12,898,098 gallons of molasses and 509,731 pounds of sugar.

You will observe that this is but a small number of the counties in the States enumerated, and that undoubtedly some of the best sugar-producing counties have been omitted.

The census of 1880 thus far contains accurate statistics from only four States, viz:

States.	Acres.	Sugar.	Molasses.
		Pounds.	*Gallons.*
Kansas	20,643	18,060	1,414,404
Louisiana	1,015	4,000	38,736
Minnesota	5,221	3,457	345,556
South Carolina	7,660	8,225	276,046

And now, gentlemen:

The further development of this business depends on the judgment and wisdom of those who are engaged in it. There seem to be several methods by which the desired result can be obtained, the choice of which is to be governed by soil, climate, and atmospheric influences. The condition of the crop depends, of course, on the state of the soil in which it is grown. The conversion of the crop into sugar depends upon the skill with which it is harvested and subjected to the various methods of manufacture—methods which may perhaps differ somewhat in different localities.

I am informed by one of the most intelligent investigators that the attempt of chemists in many localities to eliminate the acids which interfere with the successful manufacture of sugar and of clear free sirup alike have been crowned with success during the present season. He is of opinion that the work requires "the constant attention of the chemist schooled to this particular work," and he suggests that "the sorghum factories now without a certain knowledge of the juice in all its stages will fail to produce sugar in any certain quantities." This ob-

server's views of the prospect of the business in Kansas, Minnesota, Wisconsin, and Illinois are encouraging.

I have of course spoken, gentlemen, not as an expert in this matter, but as an observer whose official duty it is to encourage every branch of agriculture in our country, by wise co-operation with those who are engaged in the work of tilling the soil.

The fact that sugar can be made from sorghum has been proved. That it can be profitably made Professors Weber and Scoville have demonstrated, and have so declared to this association with their figures before them. That there is a market for the product no man doubts. Whether it is a universal crop or not, time and experience alone can prove. When I asked Professor Weber, yesterday, "What are the obstacles Professor Goessmann found in Massachusetts which render sorghum sugar-making there impracticable?" his reply was: "Shortness of the season, danger of early frosts, and an incomplete development of the cane." Who can say, as yet, that this crop will take its place among the special crops of our extreme Northern and Eastern States, or will occupy the place now filled by the sugar cane of the South? Nor is this important. Like all other agricultural products, the profit of sorghum depends on locality, soil, climate, and the commercial status of the cultivator as regards the ownership of his land; whether he possesses a plantation of thousands of acres or a small farm; whether he sets up his own sugar mill and runs a sugar plantation or depends upon a neighboring factory for his market of the crop from his few acres. We have a right to expect that it will find its place, as every other crop has done, and will be accepted in its proper sphere either for the domestic supply of molasses when convenient and economical or for conversion into sugar where circumstances are favorable. It took many years for the great cotton and woolen and iron industries to establish themselves and occupy the market, but their founders made their goods, found their market, and pocketed their profits. They worked with perseverance, economy, and great ingenuity and skill. You can follow their example.

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